

# THE ANNALS

AND

## MAGAZINE OF NATURAL HISTORY.

[FIFTH SERIES.]

No. 16. APRIL 1879.

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XXVIII.—*On the Geological Distribution of the Rhabdophora.*  
By CHARLES LAPWORTH, F.G.S.

Part I. HISTORICAL.

### *Introductory.*

THE present paper was partly written in the autumn of 1873, as a sequel to my memoir on the Improved Classification of the Rhabdophora, which was published in the 'Geological Magazine' of November and December of that year\*. Its original purpose was to show that what are there classed as closely allied genera are invariably associated in synchronous deposits in widely separated portions of the Lower Palæozoics of the northern hemisphere—the justice of the classification there proposed receiving in this way a most striking confirmation. I have deferred its publication from time to time, hoping to be able to include the general results of a personal study of the Graptolite-bearing beds of Wales and the West of England. This investigation, however, I have hitherto been unable to accomplish, owing to my want of leisure and to the all-absorbing nature of my work among the Lower Palæozoics of the South of Scotland. In some respects this delay has been an advantage; for during the interval the progress in many departments of research among the Palæozoic rocks has been

\* Geol. Mag. vol. x. dec. 1, pp. 500, 555.

very rapid. The new facts obtained, and the new views promulgated, while they fully bear out my original generalizations in all essentials, raising much that I regarded merely as a high probability almost to the rank of an absolute certainty, also enable me to add many illustrative details previously unknown.

The evidences now at our command converge most distinctly to the general conclusion that the various species, genera, and families of the Rhabdophora are quite as restricted in time as those of the more carefully studied Brachiopoda and Tribolita, and are consequently quite as reliable exponents of the systematic place of their containing beds. If, as I am inclined to believe, the Graptolites are destined to play among the Lower Palæozoics the part filled by the Ammonites among the Jurassic rocks, in fixing the minor divisions of the deeper-water beds, and in determining their parallelism in areas now geographically separated, the importance of the study of their geological distribution can hardly be overestimated. At present our accumulated evidences are insufficient to justify this broad generalization; and the combined results of the labours of many investigators are necessary before we can hope to arrive at a correct estimate of the office of the Graptolites in the Palæontogeology of the Lower Palæozoics. British geologists can no longer afford to neglect these ancient fossils, unless they are willing to be distanced by foreign investigators. Tolerably correct figures and descriptions of our commoner forms are now extant and are accessible to all. In the present article I will endeavour to summarize the main facts already determined—fixing our present point of departure in such a way that our future progress may be easily estimated, and at the same time giving a general idea of the road upon which alone success is certain.

#### (a) *Geological Difficulties.*

Previous to 1873 the necessary data for a correct estimate of the range of even the main groups of the Rhabdophora were wholly wanting. We were fully aware of the presence of identical or representative species of *Graptolithina* in numerous localities, and in many different formations, on both sides of the Atlantic; but the most erroneous views prevailed among geologists with respect to the proper parallelisms of all the more prolific of these Graptolite-bearing strata. To such an extent was this the case, that graptoliferous beds which subsequent investigations have shown to be disjoined fragments of what was originally a single and continuous

deposit, or to be at least of one and the same geologic age, were assigned in Scotland to the middle of the Llandeilo period, in England to the Caradoc, and in Bohemia to the geological horizon of the Mayhill Sandstone.

This imperfect knowledge arose in the main from two special causes—the one geological, the other palæontological. The geological cause had its origin in the physical peculiarities of the ocean-bed upon which the fossiliferous and typical Lower Palæozoic rocks of Wales were laid down. The strata composing the formations of the Caradoc and Llandovery, which occupy the central portion of Murchison's original Silurian system, are, generally speaking, arenaceous, and therefore not of a nature to afford Graptolites. Nor did they appear to be abundant in the succeeding Ludlow and Wenlock formations. For many years only three British species were known as occurring in the entire series from the base of the Caradoc to the summit of the Silurian. On the other hand, they were found to be astonishingly abundant in Murchison's lowest formation—the Llandeilo, which consisted in great part of argillaceous and more or less carbonaceous schists. When the extra-Salopian areas came to be mapped, the same rule was found to hold good everywhere—the Llandeilo furnishing *Rhabdophora* in abundance, while in the succeeding formations they were either wholly wanting or, at most, were excessively rare.

In the south of Scotland a corresponding physical accident led to the erroneous opinion that the Graptolites were as strictly Llandeilo forms as they had proved themselves in Wales. The prolific Silurians of Girvan, whose Caradoc age was demonstrated by their numerous and well-preserved Crustacea and Brachiopoda, appeared to repose at once upon those vast thicknesses of non-fossiliferous greywackes and schists that floor the Southern Uplands, and which certainly bear a striking resemblance to the infra-Caradoc rocks of Wales and the west of England. These greywackes were therefore naturally paralleled with the Llandeilo rocks of Murchison's 'Siluria.' The black carbonaceous bands that are frequently met with amongst them were necessarily regarded as of the same general geologic age. These black bands, which form the well-known Moffat series, are the most prolific Graptolite-bearing strata in Britain; and their unhesitating reference to the Llandeilo formation by Murchison was for many years regarded by geologists as one of the best-founded generalizations in British geology.

The published results of the simultaneous investigations of foreign geologists appeared to point distinctly in the

same direction. In Scandinavia, where the strata are so uniformly fossiliferous, and, at the same time, are so little disturbed that the physical and palæontological succession is unequivocal, it was clear, from the researches of Kjerulf and Angelin, that the widespreading Orthoceratite Limestone of that country was both underlain and overlain by a mass of Graptolite-schist. Enough was known of the fossils of this limestone to enable Murchison to parallel it confidently with his Llandeilo beds. The Graptolite-schists below the limestone yielded the *Phyllograpti* and *Didymograpti* of the Welsh Llandeilos; those a little above it as distinctly furnished many of the most characteristic species of the Moffat series, especially of the genera *Diplograptus* and *Monograptus*; while above this horizon Graptolites were absent. Thus not only did these Scandinavian beds afford additional proof of the general restriction of Graptolites to the Llandeilo period, but they appeared also to furnish a satisfactory demonstration of the correctness of Murchison's reference of the Moffat rocks to the Llandeilo of Wales, in which their most characteristic forms are wanting.

The strict propriety of these deductions appeared to be fully borne out by the investigations which followed. Professor Harkness and Sir Roderick Murchison, after concluding their investigations of the Graptolitic Skiddaw Slates (Lower Llandeilo &c. of Murchison), made the discovery that the Coniston Limestone of the same area of the Lake district was immediately surmounted by a group of highly fossiliferous Graptolitic shales (the Coniston Mudstones). The Coniston Limestone itself had long been universally recognized as the representative of the Bala or Caradoc Limestone of Wales; and the natural conclusion at which their discoverers arrived was that these Coniston Mudstones must also be of Caradoc age. A careful study of their Graptolites, subsequently made by Prof. Nicholson, made it clear that, palæontologically, these beds were closely allied to the Moffat series of South Scotland. At least half the Scotch forms were missing from the Coniston beds; but this was accounted for by the supposed difference in date between the two deposits, the missing forms having become extinct in Britain during the period which intervened between the Upper Llandeilo and the Upper Caradoc.

Nor did the discoveries in Bohemia, Thuringia, and on the continent of America appear to militate against these conclusions. Barrande had already shown that the strata constituting the basal zone (E e 1) of his Upper Division was crowded with Graptolites; but he also admitted, at the same time, that

they were present, though in far less abundance, in the "Colonies" imbedded in the schists of *D d 5*, the highest zone of his Inferior Division. The majority of the Bohemian forms were found to occur in the Coniston Mudstones; and the natural inference was drawn by many palæontologists that Barrande had placed the boundary between his two divisions at a lower systematic horizon than that of Murchison—an opinion Murchison himself appears to have regarded with favour ('*Siluria*,' p. 374).

In North America the first prolific graptolitic formation (the so-called Hudson-River group), detected by the New-York geologists, was the highest natural group of rocks that could with propriety be assigned to Murchison's Lower Silurian. It thus occupied a systematic position exactly equivalent to that of the Coniston Mudstone and the band *D d 5* of Bohemia. The much grander series of graptolitic rocks (the Quebec group) afterwards discovered by the Canadian geologists, were at first placed upon the same parallel; but the subsequent discovery of primordial genera within them led to their relegation to the base of the New-York system, into the exact place of Murchison's Llandeilo formation.

Thus, on both sides of the Atlantic, it appeared evident that, as regarded their vertical range and specific development, the Graptolites presented two distinct maxima—the one near the base of the Ordovician system, the other near its summit. Their total range appeared to be coincident with the limits of Murchison's original Silurian system; but, with the exception of a few scattered examples, they were wholly restricted to these two well-marked horizons.

The two maxima thus recognized in Britain and America were by no means, however, regarded as of equal importance. That at the summit of the Caradoc sank into comparative insignificance when compared with the maximum in the Llandeilo; and a tendency was soon developed among palæontologists to refer every prolific Graptolite-bearing stratum to the Llandeilo formation. Some of the examples of this tendency are very curious, as illustrative of the extent to which even the most cautious investigators will allow themselves to overlook or disregard facts when they stand in opposition to what appears to be a well-grounded generalization.

In the palæontological portion of Ramsay's '*Geology of North Wales*,' Mr. Salter assigns the black shales of Conway to the Llandeilo formation for the sole reason that, like the Llandeilo of South Wales, they contain Graptolites in more than ordinary abundance—and this in the face of the admitted fact that they are surrounded on all sides by strata either of



Caradoc or later age, and are distinctly mapped by Jukes, on physical grounds, as lying far up in the Caradoc series\*. Similar strata interbedded with the highly fossiliferous limestones of Amlwch in Anglesey are regarded as Llandeilo for a corresponding reason, in distinct opposition to the circumstance that the limestones yield typical Caradoc forms†. The black shales, traps, limestones, and grey flags that form portions of the counties of Waterford and Wexford, in the S.W. corner of Ireland, afford us another instance of the same phenomenon. These strata, much contorted, are well seen upon the shores of the triple estuary of the Suir, Nore, and Barrow, where they are, in places, abundantly fossiliferous, the calcareous beds swarming with well-known Caradoc Testacea and Crustacea, and the interbedded dark shales yielding numerous and well-preserved Graptolites. Murchison himself is said to have expressed the opinion that, while the calcareous beds ought to be assigned to the Caradoc, there could be no doubt that the fauna of the associated black shales was as distinctly Llandeilo. Jukes, from personal knowledge of the rocks, on the other hand, confidently asserted that the so-called Llandeilo forms were intimately associated physically with the beds so rich in Bala fossils, and could not be separated from the rest of the series ‡. He admitted, however, without demur the correctness of the reference of the fauna of the graptolitiferous beds to the Llandeilo formation, eluding the difficulty by expressing his opinion that “the occurrence of small assemblages of Llandeilo species here and elsewhere in Ireland in peculiar beds, which are, as far as can be determined, interstratified with the beds containing Bala or Caradoc species, reminds us of Barrande’s colonies. He had long suspected that the two assemblages of species were contemporaneous in reality, and had each their peculiar habitat, their occurrence as fossils depending on the nature of the rock, quite as much as its period of formation” §. Mr. Baily||, a few years later, cited this opinion in support of his own more correct view that similar dark shales in Central Ireland were actually of true Caradoc-Bala age—a view he finds himself compelled to adopt in this instance, as they were clearly interstratified with beds affording typical Caradoc-Bala fossils.

\* Ramsay, ‘Geology of North Wales,’ pp. 107, 259.

† Ibid. pp. 189, 258.

‡ Jukes, Mem. Geol. Surv. Ireland, Explan. Sheet 167, p. 28.

§ Ibid. p. 30.

|| Baily, Mem. Geol. Surv. Ireland, Sheets 81, 82, pp. 13, 14; Sheet 49, p. 18.

As a rule, however, the simple occurrence of black shales with Graptolites is of itself regarded as affording sufficient evidence of the Llandeilo age of the surrounding rocks \* ; and this also appears to have been the sole reason for the authoritative opinion of the Irish Survey that the black graptolitic shales of Meath and Down rose in anticlinal lines from below the barren Proterozoics of those counties. The marvellous confusion and obscurity that has been the inevitable result of these erroneous views is very naïvely summed up in Mr. Kinahan's admirable 'Geology of Ireland,' published within the last few months. According to this author the Ordovician (Cambro-Silurian) rocks of Ireland are divisible into two successive formations :—a lower (Dark shale) series, characterized generally by fossils of Llandeilo type, associated in some places, however, with Caradoc species; and a higher (Ballymoney) series, in which the assemblage of fossils "is to be compared with that of the Bala rocks, though Caradoc species are not uncommon, while † *whenever black shales occur, no matter on what horizon, they nearly always contain fossils of Llandeilo type.*"

In Scotland the same floating idea that the simple presence of Graptolites in association with black shales affords sufficient evidence of the Llandeilo age of the surrounding rocks, has had a similar influence. I have already pointed out how it weighed with Murchison in his estimate of the geological position of the typical Moffat shales themselves. On the subsequent discovery of similar black shales in the rocks of the mining district of the Leadhills, they were as unhesitatingly assigned to the Llandeilo period by the officers of the Geological Survey ‡, although some of them were known to be actually interstratified with beds crowded with Caradoc-Llandovery fossils, and at the same time were supposed to be many thousands of feet higher in the vertical series than the so-called "Upper Llandeilo" shales of Moffat. Even as late as 1872 we find similar rocks near the Mull of Galloway classed as of indubitable Llandeilo age on the evidence of a list of Graptolitic species, not one of which has ever been detected in Llandeilo rocks, or in any strata whatever lying below the base of the Llandovery §. Indeed the only palæontological evidence yet adduced of the Llandeilo age of the rocks of the Southern Uplands is the mere presence of Graptolites in seams of black shales.

\* Baily, 'Graptolites of Meath,' &c., Geol. Soc. Dublin, 1862; and Quart. Journ. Geol. Soc. London, 1869, pp. 158-162.

† Kinahan, 'Geology of Ireland,' 1878, pp. 24, 25.

‡ Memoirs Geol. Surv. Scotland, Explan. Sheet xv. p. 13.

§ Ibid. Sheet i. 1872, p. 7 and Appendix.

(b) *Palæontological Difficulties.*

The palæontological difficulties and misconceptions, though not so glaring as the geological, were nevertheless of such a nature as almost of themselves to prevent any one but a confirmed Graptolithologist placing the slightest reliance upon the typical Graptolite as a geological index of the systematic place of its containing stratum.

The title of *Graptolithus* was originally founded by Linnæus to include a group of natural objects which were regarded by him as resembling, but not being, actual fossils. Only one of the forms ultimately described by him as belonging to this family was actually a true Graptolite, as we now understand the term; and this did not make its appearance in his 'Systema' till it reached the twelfth edition. Their proper position in the animal world still remains unsettled after half a century of controversy. Relegated in turn to the Cephalopoda, Polyzoa, Actinozoa, and Hydrozoa, they are now doubtfully classed by the greatest of our modern authorities near the family of the Plumularidæ among the Hydroida, in the immediate neighbourhood of the humble Rhizopoda.

The figures and descriptions of Linnæus and Hisinger\* (who subsequently named four of the most common Scandinavian forms) were so imperfect that those palæontologists who relied upon them, and who attempted to compare them with similar extra-Scandinavian forms, fell into innumerable errors.

Linnæus's original "*Graptolithus scalaris*"†, a true monograptid, has not only been confounded with several Monograptidæ of different species, but all the more common forms of the genus *Climacograptus*, Hall, have been in turn referred to it. This general reference was considered to be so well founded by those who had most carefully studied the subject, that Linnæus' original specific name *scalaris*‡ is admitted by Hall to have actually formed the foundation of his generic term.

Linnæus' second species, "*Graptolithus sagittarius*," which was founded not upon a true Graptolite, but upon a well-marked fragment of *Lepidodendron*, was erroneously identified by Hisinger with a well-marked species of *Monograptus*. The specific name, thus interpreted, was subsequently applied to at least half a dozen different species of Monograptidæ. From 1840 to 1873 it was the general practice to refer to this species every fragment of the numerous genera belonging to

\* 'Lethæa Suecica,' 1839, and Supplement, 1840.

† Linnæus, 'Skånska Resa,' p. 147.

‡ Hall, Grapt. Quebec Group, p. 112, &c.



the much more ancient family of the *Dichograptidæ*, if its connexion with a compound form could not be satisfactorily proved.

Hisinger's *Diplograptus (Prionotus) pristis* was equally fertile of errors. It has been identified with nearly all our commoner *Diprionidæ* in turn, from the base of the Skiddaw to the horizon of the Wenlock shales. Portlock's species *Monograptus tenuis*, Barrande's species *Monograptus Nilssoni*, and Murchison's *Diplograptus foliaceus* afford us instances of the same phenomenon.

So generalized and defective were the original figures and descriptions of the graptolitic forms first detected, and so obscure or insignificant did their special characteristics appear to palæontologists, that the foregoing list could be greatly extended. Even forms belonging to the most diverse genera were long confounded. The cautious and painstaking Barrande himself placed all his *Climacograpti*\* in the genus *Monograptus*, supposing these diprionidian species to be scalariform impressions of monoprionidian forms. Hall, again, placed the whole of the genera of the *Dichograptidæ* in the genus *Monograptus* †, on the ground that the simple and unilateral character of the polypary in the latter genus was incapable of demonstration. *Retiolites* ‡ and *Diplograptus* were long confounded; and the strikingly distinct genus *Dicranograptus* remained undistinguished. Perhaps the most remarkable confusion reigned in the bifid forms. Even as late as 1873 the term *Didymograptus* was still employed by some of our greatest authorities so as to embrace forms belonging to the three groups *Didymograptus*, *Dicellograptus*, and *Leptograptus*, which are not only distinct genera, but are possibly the types of three distinct graptolitic families.

### (c) Previous Opinions.

In the face of such formidable difficulties and misconceptions, geological and palæontological, it could not but happen that the generalizations of those who attempted to fix the range of the various forms of the *Graptolitidæ* in space and time were frequently wide of the truth. Looking back, however, over the history of the progress of our exact knowledge of these fossils from our present standpoint, it becomes clear that those errors—though of sufficient moment to shake the faith of the

\* Grapt. de Bohême, pl. ii. figs. 7, 8, 14, 15; pl. iii. figs. 5, 6.

† Grapt. of Quebec Group, p. 42; Twentieth Report of State Cabinet, pp. 236, 237.

‡ Nicholson, Mon. Brit. Grapt. pp. 55, 63, &c.

general palæontologist of the time in the Graptolite as a geological index, yet compare by no means unfavourably with the preliminary efforts of systematists in other groups of fossils during the initiatory and obscure stages of their investigation.

The more noticeable efforts in this direction were the summaries in the works of Barrande, Salter, and Hall, and in the various memoirs published by Professor Nicholson.

In his classical work on the Graptolites of Bohemia, published in 1850, Barrande gave an exhaustive summary of the facts at that time recognized with respect to the geological range of the Rhabdophora\*. Misled by Professor Phillips's erroneous enumeration of *Didymograptus Murchisoni* (Beck) among the fossils afforded by the black *Olenus*-bearing shales of the Malvern Hills, and by Sedgwick's distinct assertion that the Graptolite-bearing Skiddaw slates were of the age of the Lower Cambrian, Barrande reluctantly looked upon the Graptolites as making their first appearance in, or immediately below, his Primordial zone. The upper limit of their vertical range he placed in the Ludlow formation. The epoch of their maximum development corresponded, he believed, to the middle of the Lower Palæozoic age; in other words, they reached their maximum at or near the period when the lowest beds of Murchison's original Upper Silurian formations were laid down. He recognized most distinctly the restricted range of the genera *Rastrites* and *Gladiolites*, and hinted that, in all probability, they would be found to be exclusively confined to the rocks of the third fauna. From the fact that the Rhabdophora attained their maximum development in the Llandeilo-Bala beds of the United States, Britain, and Scandinavia, while they do not become abundant in Bohemia till we reach the horizon of the Llandovery, he believed that the anteriority of the existence of the Rhabdophora in the former countries might even then be regarded as established, not only for the group as a whole, but also for many of its subordinate forms. This conclusion, which implied the presence of a fauna of a typical Silurian character in the higher strata of the Ordovician of America and North-western Europe at a time when the typical Ordovician fauna remained unchanged in the Bohemian basin, he fortified by coincident proof from the behaviour of the genera of the Crustacea and Brachiopoda; and it has often been employed by him subsequently with great effect in defence of his remarkable theories of migration and colonies.

\* Grapt. de Bohême, pp. 20-32.

Professor Hall\* confined his observations to a note of the vertical range of the *Rhabdophora* in American deposits. Their earliest appearance he showed to be in the Quebec Group of Lower Canada, at or near the general horizon of the Calciferous Sandstone of New York; they there attained their maximum development, both in genera and species. He distinguished also a second but less prolific horizon, viz. that of the Utica Shales and the Slates of Norman's Kiln in the valley of the Hudson river. These he placed at the summit of the Ordovician. The only Silurian rocks known to Hall as affording *Rhabdophora* were the shales of the Clinton formation, at the base of the Niagara group.

Mr. Salter was probably responsible for the lists of fossils appended to the several editions of Murchison's 'Siluria.' How naturally he felt impelled to assign every prolific graptolite-bearing stratum to the Llandeilo has been already pointed out. Even as late as 1868 the influence of this feeling was as apparent as ever. A glance at the list of Graptolites in the Table of British Silurian fossils, in the fourth edition of 'Siluria,' will make it evident that, if we exclude the few admitted Wenlock forms and the half-dozen species from the beds of Pomeroy and Girvan (whose occurrence in strata crowded with Bala Crustacea made it imperative upon the conscientious palæontologist to give them a place in the Caradoc column), almost all the British *Rhabdophora* are assigned to the Llandeilo. Of the fifty-one species there cited, forty are placed in the Llandeilo column; and thirty-eight of these were tabled as peculiar to that formation. Three species (*Climacograptus scalaris*, His., *Monograptus convolutus*, His., and *Monograptus Sedgwickii*, Portlk.) are given as common to the Llandeilo and Caradoc beds. *Climacograptus bullatus*, Salt., *Monograptus Conybeari*, Portlk., *Monograptus griestonensis*, Nicol, are noted as peculiar to the Caradoc, in all probability for the reasons given above. Beyond *Monograptus priodon*, Bronn, whose range is mentioned as extending from the Caradoc to the Ludlow, no Graptolite is noted as common to both the Ordovician and Silurian. To the latter only two other species are assigned—*Monograptus Flemingii*, Salter, and *Retiolites Geinitzianns*, Barr.

Professor H. A. Nicholson has made this question the subject of several important memoirs. In a paper contributed to the 'Annals and Magazine of Natural History' in 1868, he treated of the "Distribution in Time of the British Genera and

\* Grapt. Quebec Group, pp. 51-58.

Species of the Graptolites" \*, deriving many of the more important of his data from the results of his own extended researches. In this paper the range of the Rhabdophora was defined as extending from the base of the Skiddaw (Arenig) series to the summit of the Ludlow formation. The restriction of *Dichograptus*, *Tetragraptus*, and *Phyllograptus* to strata of Lower Ordovician date (Skiddaw) was pointed out, and the local stratigraphic position of many genera most carefully given. The general conclusions drawn by the author from the data before him are of great historical value, as showing the rapid advance in our knowledge of the distribution of these fossils within the last few years. To one who is at all familiar with the facts recently made known regarding the special horizons marked by these forms, it is interesting to read that *Climacograptus* and *Diplograptus* are exclusively Ordovician genera, that *Rastrites* and *Cyrtograptus* are unknown above the Caradoc rocks, and that the genus *Monograptus* (*Graptolites*) ranges from the Skiddaw Slate to the summit of the Silurian.

In his 'Monograph of the British Graptolitidæ,' published in 1872, Professor Nicholson treats of the geological distribution of the Rhabdophora in some detail. The graptolitiferous Lower Palæozoics of Britain are regarded by him as belonging to three successive periods. To the first of the periods (the Skiddaw or Arenig period) are assigned the genera *Trigonograptus*, *Climacograptus*, *Diplograptus*, and *Didymograptus* and its allies. In the second period (that of the Llandeilo-Caradoc formations) are placed the genera *Diplograptus*, *Climacograptus*, *Didymograptus*, *Dicranograptus*, *Cænograptus*, *Pleurograptus*, *Cyrtograptus*, *Rastrites*, *Retiolites*, and *Monograptus*. In the (Upper) Silurian the author only admits the presence of the genera *Diplograptus* and *Climacograptus*, but in Bohemia only, observing, "but for this as yet solitary exception, it might have been asserted that no diprionidian Graptolite, save the aberrant *Retiolites*, occurred in rocks younger than Murchison's Lower Silurian" †.

The general tendencies of the foregoing conclusions, read in the light of the favourite palæontological speculations of the time, are ably summed up by this author in his paper on the Migrations of the Graptolites, published during the same year ‡.

In this memoir Dr. Nicholson accepts, without reserve, the generally received opinions with respect to the systematic

\* Ann. & Mag. Nat. Hist. 1868, ii. pp. 347-357.

† Mon. Brit. Grapt. pp. 92-98.

‡ Quart. Journ. Geol. Soc. London, 1872.

place of the various graptolitiferous deposits of Europe and America; and, basing his argument on his intimate knowledge of their included and peculiar forms, he endeavours to trace out the progress of the several genera and species, both in space and time. He infers that the evidences at his command show that the Skiddaw forms migrated southwards and westwards into Wales, Ireland, and America. Four species emigrated northwards into the Moffat area of the south of Scotland. This Moffat area became subsequently the birth-place of the genera *Retiolites*, *Cænograptus*, *Rastrites*, and, most probably, *Pleurograptus* and *Monograptus*. It formed in its turn a grand centre of dispersion. To the south it furnished 55 per cent. of the later Coniston-Mudstone fauna. Its western emigrants, after peopling the Caradoc beds of the south of Ireland, crossed what is now the Atlantic, and reappeared in great force in the Utica Slates and Lorraine Shales at the summit of the Ordovician of New York and Canada. Easterly the course of the Moffat forms can be even more satisfactorily followed, their first resting-place being the Greywacke area of Saxony, whence they subsequently passed southwards into Barrandé's Colonies and the band *Ee 1* of the Bohemian Basin.

[To be continued.]

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XXIX.—*On the Occurrence of a small and new Phyllopod Crustacean, referable to the Genus Leaia, in the Lower Carboniferous Rocks of the Edinburgh Neighbourhood.* By R. ETHERIDGE, JUN., F.G.S., of the British Museum.

THE rapid increase in the number of invertebrate species lately discovered in the Calciferous Sandstone or Lower Carboniferous rocks of the south-east of Scotland, through the researches of the Geological Survey and of private collectors, has in a great measure tended to bridge over the gap which was formerly supposed to exist between the two important subdivisions of the Carboniferous system in Scotland—the Calciferous Sandstone series and the Carboniferous Limestone.

In continuing this subject\* it is with much pleasure that I have to chronicle the discovery, by Mr. James Bennie, of a

\* "On our Present Knowledge of the Invertebrate Fauna of the Lower Carboniferous, or Calciferous Sandstone Series, of the Edinburgh Neighbourhood, especially of that Division known as the Wardie Shales," Quart. Journ. Geol. Soc. 1878, xxxiv. p. 1.